Nutritional Support in Critically Ill Patients

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ABSTRACT

Critically ill patient is at risk of malnutrition. The aim of nutritional support is to prevent malnutrition and its complication, and also fulfill macro- and micronutrient, reduce nitrogen deficit, and improve inflammaroty response. In critica patient with stable hemodynamic, enteral nutrition should be started early at 24-48 hours while patient not in ebb/resuscitation phase. Parenteral nutrition is not recommended in the first 24 hours of ICU care if enteral feeding is feasible. Parenteral nutrition is considered after 5-7 days, except poor enteral condition. Delay of parenteral nutrition for 7 days reduce risk of infection, increase recovery time, and reduce cost. On the first day, calorie should reach one third of actual need, increased to half to two third on second day, and full calorie on the third day. Total calorie need is 25-35 kcal/ideal bodyweight. Source of calorie is 60-70% carbohydrate and 30-40% lipid. Daily fluid need is 30-40 mL/kgBW/day or 1.0 – 1.5 mL/kcal calorie intake. Several important micronutrients to fulfill is sodium, potassium, calcium, phosphate, and magnesium. Three main consideration of nutritional support is route, type of formula, and when to start nutritional support.

Keywords: *nutritional support, critical condition, fluid, calorie*

ABSTRAK

Pasien dengan penyakit kritis berisiko tinggi mengalami malnutrisi. Tujuan utama dukungan nutrisi adalah untuk mencegah malnutrisi dan komplikasinya dengan memberikan makro dan mikronutrient sesuai kebutuhan, mengurangi defisit nitrogen dan pengaturan respon inflamasi. Pada pasien kritis dengan hemodinamik stabil pemberian nutrisi enteral sebaiknya diberikan dini dalam 24-48 jam pertama dan saat pasien tidak dalam fase ebb/resusitasi. Pemberian nutrisi parenteral tidak dianjurkan diberikan dalam 24 jam pertama perawatan ICU jika nutrisi enteral dapat diberikan. Nutrisi melalui parenteral baru diberikan di atas hari ke 5-7, kecuali kondisi enteral tidak memungkinkan. Penundaan nutrisi parenteral di atas hari ke 8 terkait dengan infeksi yang lebih sedikit, mempercepat penyembuhan dan mengurangi biaya perawatan. Pada hari pertama dapat diberikan 1/3 kebutuhan kalori, hari kedua 1/2-2/3 kalori dan pada hari ketiga dapat diberikan dukungan penuh. Kebutuhan kalori total dapat digunakan rumus 25-35 kkal/kgBB ideal. Kebutuhan kalori didapatkan dari 60-70% karbohidrat dan 30-40% lemak. Kebutuhan cairan adalah 30-40 ml/kgBB/hari atau 1-1.5 mL/kkal dari kalori yang diberikan. Beberapa mikronutrient penting untuk dipenuhi adalah natrium, kalium, kalsium, fosfat, dan magnesium. Tiga hal yang harus diperhatikan dalam menentukan terapi nutrisi adalah rute pemberian, formula yang akan diberikan dan kapan akan memulai pemberian nutrisi.

Kata kunci: *terapi nutrisi, kondisi kritis, cairan, kalori*

INTRODUCTION

Acute critical conditions such as trauma, burn, surgery, or severe infection need a special approach. This condition should be treated fast and comprehensive. Mutiorgan damage is common in this situation thus additional support such as mechanical ventilation, hemodialysis, and nutritional support is important.[1] Nutritional support has a direct impact on patient outcome during intensive care. Malnutrition is found among 40% of high risk critical patients.[2] Around 60% of patient admitted to intensive care unit (ICU) have a digestive problem, such as motility disorder or malabsorption. Low calorie intake was also common and could lead to energy deficit and body mass loss.[3] The aim of nutritional support is to prevent malnutrition and its complication by giving the sufficient amount of both macro- and micronutrient to reduce nitrogen deficit and inflammatory response.[2]

Previously, nutritional aspect in intensive care was limited to supportive care, while in recent years it has been shifted to become a treatment since it improve metabolic response to stress, prevet oxidative tissue damage, and support immune system. Therefore, nutritional support is expected to maintain lean mass, reduce autocanibalism, reduce infection, improve wound healing, maintain digestive function, maintain kidney and liver function, reduce hospitality duration, and also mortality.[4]

METABOLIC RESPONSE IN CRITICALLY ILL CONDITION

In critically ill condition, metabolic response cause hypermetabolism and hypercatabolism that lead to body mass loss and further increase morbidity.[1,2,5] This catabolic response was worse than healthy fasting individual because of its high inflammatory response.[6] In critical patients, stress was begin with ebb phase (shock, resuscitation) and flow phase (acute phase). During ebb phase, hemodiamic was unstable, blood pressure is low, stroke volume is reduce, oxygen utility is low, and low body temperature followed by high glucagon, catecolamin, and free faty acid level.

This process last for 12-24 hours and treatment focus is on fluid resuscitation and hemodynamic stabilization. On the next phase, flow phase, body response is aim to repair any tissue damage. Endogenous substrat such as glycogen, amino acid, and free faty acid are actively released. During this phase, nutritional support played an important role.

During sepsis, increase of tumor necrosis factor (TNF) alpha and interleukin 1 secretion lead to liver injury, increase glucose tolerance, and protein catabolism. Although could not prevent catabolism process, nutritional support could increase protein synthesis and reduce overall protein loss.[5]

NUTRITIONAL STATUS ASSESSMENT

The aim of nutritional assessment is to identify which patient having or at risk of malnutrition, its severity, and monitor the response of current nutritional support. In history taking, an information such as previous history of illness, daily nutritional intake, gastrointestinal complaints, and weight loss should be assessed. Several important information is weight loss of 10% or more in last 6 months, weight loss of 5% or more in the last month, or weight status more or less than 20% of ideal body weight.[1,7] Physical examination that should be done is body mass index measurement.[1] Arm circumference and triceps muscle thickness is also commonly used, but have a high error rate.[7] Body weight measurement is not reliable in critical condition, especially in edema condition.[4] Table 1 shows malnutrition categories based on laboratory indicators. Prealbumin is an important indicator of visceral protein reserves.[1] Reduce albumin level is an acute phase response, but rarely used as malnutrition marker since it is not specific.[4,7] Transferrin is also another laboratory indicator that have poor diagnostic performance.[7] Subjective global assessment that measure weight loss, calorie intake week before admission, disease progression, comorbidity, and digestive system function classify malnutrition as normal, moderate, and severe.[4]

Table 1. Nutritional status based on laboratory examination[1]

Laboratory indicator	Half-life time ($T_{1/2}$)	Nutritional status			
		Normal	Mild depletion	Moderate	Severe
Albumin (g/dL)	20 days	>3,5	2.8-3.5	2.2-2.8	< 2.2
Transferin (mg/dL)	9 days	>200	150-200	100-150	<100
Prealbumin (mg/dL)	1-2 days	>18	10-18	5-10	< 5

NUTRITIONAL PROBLEM ASSESMENT

Firstly, we must determine the problem that patient have: no food intake, fasted by physician, or inadequate intake. Next, we should determine any indication and contraindication of oral, enteral, and parenteral nutrition administration. Patient with decreased consciousness is indicated for full nutritional support. Enteral route was chosen if no gastrointestinal disfunction found. On the other hand, parenteral nutrition is the first choice of diffuse peritonitis, bowel obstruction, vomiting, paralitic ileus, and gastrointestinal ischaemia. We should also assess how long would the patient need nutritional support.[1]

TREATMENT APPROACH

In critical patient with stable vital sign and hemodynamic, enteral nutrition administration should begi in the first 24-48 hours and after patient pass the ebb phase.[1,3,4] Pareteral nutrition is not recommended in the first 24 hours of ICU admission if enteral nutrition is feasible.[8] Enteral nutrition has benefits on gut mucosal integrity, prevent bacterial translocation, and maintain gut lymphoid tissue so that partenteral nutrition could be administered on day 5-7, except enteral nutrition is contraindicated.[4] Postponing parenteral nutrition for 8 days or more are associated with lower infection rate, faster recovery, and less hospital stay cost.[8]

In critical patient with unstable vital sign and hemodynamics (high lactate level or using high-dose vassopresore) enteral nutrition should be pending until basic resuscitation is finished. Several observational researchs showed that in hemodynamically unstable patient, early enteral nutrition administration lead to better survival rate.[10] Calorie intake should be given step by step to ensure gut tolerance in enteral route or to prevent negative nitrogen balance in parenteral route. On the first day, calorie intake should be around one thirs, increase to two third on the next day, and full calorie on the third dat.[1,4]

Practically, daily nutrition need could be counted as 25-35 kcal per kg ideal body weight or around 1500-2500 kcal/day.[1,7] European Society for Clinical Nutrition and Metabolism (ESPEN) recommend 20-25 kcal/kgBW/day in acute phase and increase to 25-30 kcal/kgBW/day during anabolic phase.[9] Indirect calorimetry is the most accurate method to assess daily calorie need in critically ill patient but found to be inefficient and impractical.[4] The composition of nutritional treatment is 60-70% of carbohydrate and 30-40% from fat. Calorie from protein should not be counted, but still controversial in several clinical practice.[1,4]

Carbohydrate metabolism increase CO_2 production, expressed as respiratory quotient (RQ) that was a ratio of carbohydrate production and oxygen consumption. Normal value of RQ affected from fat, carbohydrate, and protein. RQ > 1 showed excessive carbohydrate administration. This would lead to more CO_2 production that coseuently lead to ventilator-dependent case. Therefore, in patient with lung disorder, carbohydrate intake should be reduce and replaced by fat as much as 50%.[1] In critical condition, daily protein need is 1.2-2 g/kg actual BW/day.[1,4] In chronic kidney disease without dialysis, protein intake should be reduced to 0.6-0.8 g/kgBW/day, while in dialysis patient it could be doubled to 1.2-1.3 g/kgBW/day or 1.0/kgBW/day in continuous hemofiltration patient.[1]

In patient with acute kidney injury (AKI), administration of essential and nonessential amino acid should be equal and no protein restriction is recommended.[4] In AKI with severe malutritio or hypercatabolic condition, protein intake should be increase to 1.5-1.8 g/kgBW/day.[1] If patient undergo dialysis or renal replacement therapy, protei intake must be as high as 2.5 g/kgBW/day.[4]

In compensated liver cirrhosis patient, recommended protein intake is 1.0-1.2 g/kgBW/day and could be increased to 1.5 g/kgBW/day if malnutrition present. No protei restriction during this condition, except in hepatic encephalopathy. In grade I-II hepatic encephalopathy, protein intake should be as low as 0.5 g/kgBW/day and gradually increased to 1.0-1.5 g/kgBW/day. If intoleration present, patient could be given branched chain amino acid (BCAA) supplement such as isoleusin, leusin, and valin. I grade III-IV hepatic encephalopathy, protein intake vary from 0.5 to 1.2 g/kgBW/day, mainly amino acid. During this condition, there was imbalance between BCAA and aromatic amino acid both in plasma or central nervous system that manifest as consciousness disorder.[1,4] BCAA need increase to 2-4 g/day in sepsis, trauma, or acute critical condition.[7] Daily tryptophan need is around 0.25 g/day while other amino acid is 1 g/day.[7]

Several study administer other type of amino acid such as glutamine, arginine, and others to improve immune system. Enteral glutamie should be considered in burn or trauma patient.[1] Balance amino acid administration to prevent catabolism is also reported.[1] Meanwhile, a literature stated that glutamine supplementation is not recommended at the early phase of critical condition. Mechanism of

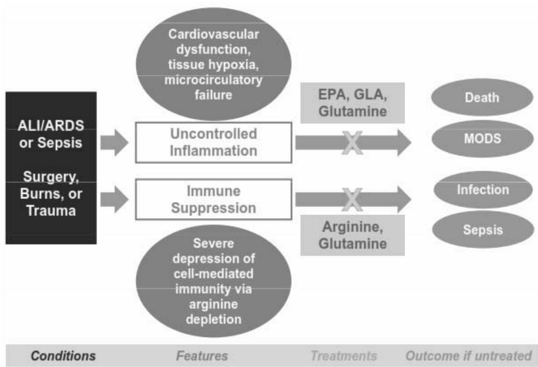

Figure 1. Mechanism of glutamine and arginine to improve critically ill patient condition

glutamine and arginine to improve patient condition is shown in Figure 1.[11]

FLUID AND ELECTROLYTE REQUIREMENT

Critically ill patient need different fluid administration, both by the amount and the type of the fluid. In general, daily need of fluid is 30-40 mL/kgBW/day or 1-1.5 mL/kcal calorie intake.[1] This requirement vary between every clinical condition. Natrium played an important role in plasma osmolality since it is the main cation of extracellular space. Kalium is needed for protein synthesis, around 6 mmol/g nitrogen for optimal amino acid metabolism. Kalium need increase during the early period of total parenteral nutrition. Kalium requirement increase as glucose intakte increase, so close monitoring is important to prevent hypoglycemia.[1]

Calcium supplementation is needed in long term parenteral nutrition therapy as a consequence of immobilization. Calcium also needed for several critical condition such as pancreaatitis. Phosphate is needed for bone metabolism, tissue synthesis, and ATP phosphorylation. Hypophosphatemia would occur during parenteral nutrition that not supplemented by phosphate. One of the worst condition is low erythrocyte level that makes oxygen delivery to tissue reduce and impar respiratory system.[1]

Magnesium is also an important micronutrient during anabolism and enzymatic reaction, mainly in brain dan liver. Magnesium reuirement increase in diarrhea, polyuria, pancreatitis, and hypermetabolic condition.[1]

VITAMIN AND MINERAL REQUIREMENT

Vitamin and minerals is an essential nutrition act as coenzyme and cofactor of several metabolic process. Deficiency of water soluble vitamin is common in critically ill patient. During long-term total parenteral nutrition, folate deficiency lead to pancytopenia, thiamine deficiency to encephalopathy, and vitamin K deficiency to hypoprothrombinemia. Intravenous vitamins need is larger than enteral route.

Chromium is needed for normal glucose metabolism. Copper is used mainly for erythrocyte maturation and fat metabolism. Iodine used for thyroxin synthesis. Iron is the backcone of hemoglobin synthesis. Mangan is used for calcium or phosphorous metabolism, reproduction, and also growth. Molybdenum is a component of oxidation while selenium for glutation peroxidase. Zinc is the main substances for enzyme production. Zinc deficiency in several weeks manifest as dermatitis and chronic wound.

NUTRITION ADMINISTRATION ROUTE ENTERAL NUTRITION

Enteral nutrition is an approach used for patient who do not want or cannot have nutritional intake orally but have normal gastrointestinal function.[1] The benefits of enteral nutrition is: (1) It is a physiologic nutrition that maintain function and structure of digestive organs; (2) For effective to increase body weight and positive nitrogen balance; (3) Less complication compared to parenteral nutrition; (4) High calorie need is easier to reach; (5) The use of nasogastric tube is easier for physician and nurses; (6) Cost less 10-20 times from parenteral nutrition.

The requisite of enteral nutrition is: (1) Nutritiona fluid is calorie-dense, ideally 1 kcal/mL to 1.5-2 kcal/mL; (2) Balance nutritional composition, mainly on protein and electrolyte, (3) Have similar osmolality to plasma, ideally 350-400 mOsm, (4) Easy to be absorbed, (5) Contain no or less fiber and lactose, (6) Free from purin and cholesterol. Enteral nutrition also activate splancnic and neuronal activity, thus induce IgA and other digestion enzyme secreation. In general, enteral nutrition is mre recommended than parenteral nutrition.[11]

Indication

Patient that cannot having adequate calorie intake but no sign of impair gastrointestinal function.[1] All patient that predict to not haceing dull oral feeding in the next 3 days. Specific indication for enteral feeding is severe dyaphagia, coma or delirium, persisten anorexia, mausea and vomiting, gastric or duodenal obstruction, fistula in small or large bowel, severe malnutrition, recurrent aspiration, and other problems that need caregiver. Contraindication of enteral nutrition is total intestinal obstruction, paralytic kalium, pseudointestinal obstruction, severe diarrhea, or malabsorption as a cause of severe pancreas hemorrhage.[1,4]

Enteral Feeding Formula

Several formula is available both in commercial or hospital-based production. Commercial formula is in a powder or fluid form and could be administered directly to gastric tube with minimal contamination risk. Otherwise, hospital-based formula is using blended food. Based on its substances, enteral formula could be devied into blended (natural), polymer fluid, monomer fluid, and nutrition for special needs. [1]

Enteral formula that could increase immune function (arginine, glutamine, fat emulsion, and antioxidant) is needed for major surgery, trauma, burn, cancer of nasphyarinx, or patient using ventilator. Patient with acute heart failure and impending respiratory failure should be given normal calorie, more omerga 3 fish, and antioxidant (recommended grade A).[9,11] In ICU, important monitoring for nutritional support is route of administration, time to start enteral nutrition, and the type of the milk. In ICU settings, method to have accurate formula should be seen below

Enteral Nutrition Tube

Based on its route, enteral nutrition tube divided into nasoenteric and enterostomy tube. Nasoenteric tube inserted via nose (nasogastric, nasoenteral). This tube used for short term nutritional therapy (less than 4 weeks) because of its less complication, lower cost, and easy to use. Enterostomy tube is a pipe inserted via abdominal wall (gastrostomy, duodenostomy, jejunostomy). This tube used for a long term (more than 30 days) or in patient with obstruction in upper gastrointestinal tract. Enterostomy tube inserted by surgical (laparotomy, laparoscopy), radiologic, or endoscopic approach. The last approach is the most commonly used: percutaneous endoscopic gastrostomy (PEG) and percutaneous endoscopic jejunostomy (PEJ).[1]

In emergency or critically ill patient, the most commonly used tube is nasogastric tube. This tube has 8-16 French size. The larger size used for nasoduodenum and nasojejenum tube while the smaller used for nasogastric tube.[1]

Enteral nutrition in critical patient should be administered in the first 24-72 hours to maintain gastrointestinal tract function. Nutritional requirement could be advanced step by step to reach full calorie on third day.[1,4] During enteral nutrition administration, patient should at elevated head 30-45 degree.[1] There are two way to deliver fluid: bolus or continuous. Bolus delivery only used if tip of the tube is on the stomach, because pyloric sphincter will naturally regulate the

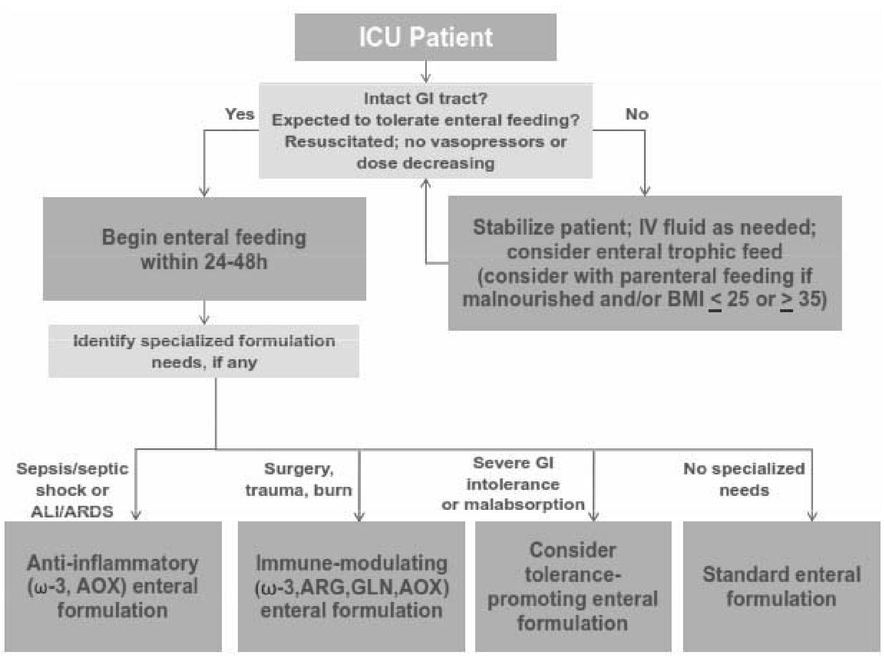

Figure 2. Algorith in choosing nutritional formula for ICU patient

amount of fluid entering duodenum. Otherwise, if tip of the tube is on duodenum or jejenum, fluid delivery should be continuous to prevent intestinal distention.[1] In bolus delivery, nutrition administration divided into six times of 250-350 mL each (every 3-5 hours) for 15 minutes. Before and after fluid delivery, tube should be washed with 20-30 mL of water to prevent hypertonic dehydration and protein coagulation on the wall of tube. In continuous delivery, fluid administration speed is around 150 mL/hour. Ileus, no flatulence and no faeces is not a contraindication of enteral nutrition, but postpyloric continuous nutrition is preferable.[4,11] Several prokinetic agent such as erythromycin or metochlopramid 4x10 mg intravenous is recommended in feeding intolerance cases.[1,9]

PARENTERAL NUTRITION

Parenteral nutrition is a method to deliver nutrition intravascular. Indication of parenteral nutrition is to maintain and improve nutritional and metabolic status of critical patient. Several specific indication of parenteral nutrition is: (1) Malabsorption syndrome with profound fluid and electrolyte loss that unable to be corrected by oral or enteral route. This syndrome is found in short bowel syndrome, severe infection, inflammation, immunologic disturbance, use of multiple drugs and radiation, high output gastrointestinal fistula, and severe renal tubular disorder; (2) Motility disorder (persisten ileus, severe intestinal pseudoobstruction, severe vomiting caused by drugs, brain tumor, and other related disease; (3) Mechanical obstruction that not yet surgically relieved; (4) Perioperative period with severe malnutrition; (5) Critical patient contraindicated to or failure from enteral feeding.

Parenteral nutrition should be administered via peripheral or central venous access. Several consideration is: (1) Peripheral vein access: in discontinued enteral nutrition but expected to be continued soon in 5-7 days, as additional to enteral nutrition, mild to moderate malnutrition, normal or slightly increase metabolism, no organ failure that need fluid restriction, and nutritional fluid osmolality below 900 mOsm; (2) Central vein access: could not tolerate enteral feeding more than 7 days, moderate to severe high metabolic demand, severe malnutrition, chronic heart failure, renal failure, liver failure, or other condition need fluid restriction, and nutritional fluid osmolality higher than 900 mOsm.[4]

In ICU patient, nutrition administration is mostly via central venous catheter. Commercial nutrition consist of (1) carbohydrate or calorie: dextrose 5%, 10%, 40%, Triofusin 500; (2) Carbohydrate and electrolyte: Triparen-1, Triparen-2, Triofusin E-1000; (3) amino acid: aminovel 600, Pan Amin G, Aminofusin; (4) BCAA: aminoleban, comafusin; (5) Fat: lipid 10%, 20%. It is more recommended to use all-in-one nutritional fluid.[4,6]

In patient intolerance to enteral nutrition, European guideline suggest parenteral nutrition at first 24-48 hous, especially if patient predicted would not have enteral nutrition in 3 days.[12,13] ASPEN recommend fluid administration first, then parenteral nutrition after 7 days.[11] Both ASPEN and ESPEN suggest parenteral nutrition in malnourished patient, but not for patient receive enteral feeding.[9]

COMPLICATION

Main complication is fluid overload, hyperglycemia, underfeeding, adn refeeding syndrome. Overload mainly found in patient with renal or cardiac failure. Hyperglycemia is found in around 27% of patient, mostly related to prediabetic condition or systemic inflammatory response (SIRS) that lead to cathecolamin and corticosteroid release, increase gluconeogenesis, insulin resistance, and impari glucose utilization. Hyperglycemia is related to high

Table 2. Indication of parenteral nutrition in critical patient[4]

Healthy patient, no protein-calorie malnutrition at the beginning	
Enteral route not feasible	Parenteral nutrition only after 7 days
Do not reach 100% nutritional target at day 7	Total parenteral nutrition start at day 7
Calorie-protein malnutrition at admission	
Enteral route not feasible	Start parenteral nutrition soon
Upper digestive tract surgery, enteral route not feasible	
Malnourish patient	Parenteral nutrition start at day 5-7 preoperative
	Elective surgery, postponed for 5-7 days
	Parenteral nutrition continued until enteral nutrition feasible
Previously healthy, no malnutrition	Parenteral nutrition should not be started early, only if enteral nutrition inadequate after 5-7 days
	Parenteral nutrition administration for <5-7 days to not have benefit
	Parenteral nutrition should start if expected parenteral rout > 7 days

mortality and morbidity. Refeeding syndrome could occur in patient that receive full nutrition in previousy severe chronic malnutrition condition. Risk factors of refeeding syndrome is BMI < 16 kg/m^2, weight loss >15% in 3-6 months, no or minimal nutritional intake in the last 10 days, adn los phosphate, potassium, and magnesium serum level. If nutritional requirement fulfilled, there was an intracellular shift of phosphate, magnesium potassium, and thiamine. This could lead to arrythmia, left heart failure, pulmonary edema, and shock. Other complications are rhabdomyolisis, dyspnea, metabolic acidosis, confusion, paresthesia, and tetany. Refeeding syndrome can be prevent by starting nutrition ad 5-10 kcal/kgBW/day and increase gradually in 4-7 days.[14]

Complication of enteral nutrition are diarrhea, tube dislocation, obstruction, or inadequate calorie intake. Early nutrition administration proven to reduce mortality for 50% but also increase risk of infection by 50%. Several complication of parenteral nutrition is catheter movement, as a consequence, local hematoma, infection, vein thrombosis, and pneumothorax could occur.[4]

MONITORING

During nutritional administration, patient should be closely monitored for abdominal distention, pain, and bloating. Residual food in stomach should be aspiraten every 6 hours with 50cc volume of tolerance. If large amount of residual found, tube insertion to duodenum or jejenum is recommended. If diarrheal occur, investigation on etiology of infection or osmotic cause should be conducted.[4] Patient receive parenteral nutrition should have monitoring on glucose level several times a day and BUN, creatinine, electrolyte, bicarbonate, phosphate, calcium, magnesium, and albumin, minimum every 1 week.

CONCLUSION

Nutritional therapy is an important factor to support patient recovery in critical condition. In choosing right nutrition, three aspect should be considered: route, type of formula, and when to start feeding

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